Advantages and Disadvantages of Internet Research Surveys: Evidence from the Literature

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E-mail and World Wide Web surveys have been the subject of much hyperbole about their capabilities as well as some criticism of their limitations. In this report, the authors examine what is known and not known about the use of the Internet for surveying. Specifically, they consider evidence in the literature regarding response rates, timeliness, data quality, and cost. Using this evidence, the authors evaluate popular claims that Internet-based surveys can be conducted more quickly, effectively, cheaply, and/or easily than surveys conducted via conventional modes. They find that the realities of cost and speed often do not live up to the hype. Nonetheless, it is possible to implement Internet-based surveys in ways that are effective and cost-efficient. The authors conclude that the Internet will continue to grow in importance for conducting certain types of research surveys.

With the advent of the World Wide Web (Web or WWW) and electronic mail (e-mail), the Internet has opened up new vistas in surveying. Rather than being mailed a paper survey, a respondent can now be given a hyperlink to a Web site containing the survey. Or, in an e-mail survey, a questionnaire can be sent to a respondent via e-mail, possibly as an attachment.

As either an alternative or an adjunct to conventional survey modes (e.g., the telephone, mail, and face-to-face interviewing), Internet-based surveying offers unique new capabilities. For example, a Web survey can incorporate multimedia graphics and sound into the survey instrument relatively simply. Similarly, other features once restricted to more expensive, interviewer-assisted modes (i.e., automatic branching and the real-time randomization of survey questions and/or answers) can be incorporated into self-administered Web (and some e-mail) surveys. However, not unlike when phone and mail surveys were first introduced, there are concerns about whether these

The helpful and substantive comments of three anonymous reviewers and the editor significantly improved this work. Our research was supported by RAND as part of its continuing program of independent research.

Field Methods, Vol. 14, No. 4, November 2002 347–367
DOI: 10.1177/152582202237725

Internet-based surveys are scientifically valid and how they are best conducted.

In the late 1980s and early 1990s, prior to the widespread availability of the Web, e-mail was first explored as a survey mode. As with the Web, e-mail offers the possibility of the nearly instantaneous transmission of surveys to recipients while avoiding postal costs. Early e-mails were primarily ASCII text based, with rudimentary formatting at best, which tended to limit their length and scope. Their only significant advantage over paper was a potential decrease in delivery and response times, although some also hypothesized that the novelty of the new medium might enhance response rates (Parker 1992; Zhang 2000).

The Web started to become widely available in the early to mid-1990s and quickly supplanted e-mail as the Internet survey medium of choice because it was easy to use, provided an improved interface with respondents, and offered the possibility of multimedia and interactive surveys containing audio and video. For convenience samples, the Web also offered a way around the necessity of having to know respondents' e-mail addresses. As a result, "quick polls" and other types of entertainment surveys have become increasingly popular and widespread on the Web.

Internet-based surveys are now in vogue—those conducted via the Web in particular—because of three assumptions: (1) Internet-based surveys are much cheaper to conduct; (2) Internet-based surveys are faster; and (3) when combined with other survey modes, Internet-based surveys yield higher response rates than conventional survey modes alone. Does the evidence in the literature confirm these assumptions? Are Internet-based surveys faster, better, cheaper, and/or easier than surveys conducted via conventional modes? What can we conclude about the strengths and current limitations of Internet-based surveying from the literature?

In this report, we synthesize the literature about the use of the Internet (e-mail and the Web) in the survey process. Other accounts of the literature include those of Schonlau, Fricker, and Elliott (2002); Couper (2000); Dillman (2000); and Tuten, Urban, and Bosnjak (forthcoming). In addition, an extensive source of Web survey literature can be found on the Web at http://www.websm.org.

LITERATURE SUMMARY FOR INTERNET-BASED SURVEYS

In this section, we summarize key characteristics of Internet-based surveys—that is, surveys using the Web or e-mail as a response mode—as documented

in the literature. We employed a professional librarian to conduct a thorough literature search in the Social Science Database and the Conference Paper Index database. The Social Science Database indexes more than fifteen hundred of the most important worldwide social sciences journals published since 1972. Additional articles relevant to the social sciences are also incorporated from over twenty-four hundred journals in the natural, physical, and biomedical sciences. The Conference Paper Index provides access to records of the more than one hundred thousand scientific and technical papers presented at over one thousand major regional, national, and international meetings each year since 1973.

The literature search yielded fifty-seven articles and papers that are substantively relevant, meaning that they describe carefully conducted Internet-based research survey efforts in sufficient detail that we could extract the necessary information from which to make comparisons. Here, we report on a subset of those articles of direct relevance to this discussion. (Appendix B of Schonlau, Fricker, and Elliott 2002 lists fifty-two articles and papers, and we have augmented this list with an additional five that have appeared since that monograph was published.)

We consider the following key characteristics of surveys: (1) response rate, (2) timeliness, (3) data quality, and (4) cost. We compare what has been published in the literature about Internet-based surveys to the natural conventional survey alternative: mail. Although no survey mode is going to be optimal in all of these areas, we chose mail because both mail and Internet-based surveys are self-administered, mail surveys tend to be the least expensive of the conventional modes, and virtually all the comparisons made in the literature are to mail surveys.

Response Rates

A standard way to summarize survey performance is by comparing response rates among various survey modes. By "survey mode" (sometimes called response mode), we mean the mode by which the survey itself is conducted: Web, e-mail, mail, and so on. In this section, we compare response rates for studies classified into three categories: (1) surveys using probability sampling or conducting censuses that used the Web as the only response mode; (2) surveys in which respondents were allowed to choose one of several response modes, including at least one Internet-based response mode; and (3) surveys in which respondents were assigned one of several response modes, including at least one Internet-based response mode.

We begin with results for studies that used the Web as the primary or only response mode with either censuses or probability samples (Table 1). Table 1

TABLE 1
Response Rates for Web-Only Surveys Using Probability Samples or Censuses

Survey	Sample Size	Response Rate (%)	Population
Couper, Traugott, and Lamias (2001)	1,602	42[a]	University of Michigan students
Asch (personal communication, 2001)[b]	14,150	8	College-bound high school students and college students
Everingham (personal communication, 2001)	1,298	44	RAND employees
Jones and Pitt (1999)	200	19	University staff members
Dillman et al. (1998)[c]	9,522	41	Purchasers of computer products
Dillman et al. (1998)[d]	2,466	38	Purchasers of computer products

a. Another 5.6% of partially completed surveys were also received.
b. Most respondents were contacted via their parents, which reduced the response rate. A mail response mode was added late in the survey protocol.
c. A relatively plain Web survey design was used in this experimental arm.
d. A relatively fancy Web survey design was used in this experimental arm.

is ordered by year, and it shows that Web-only research surveys have currently achieved only fairly modest response rates, at least as documented in the literature.

In fact, the results in Table 1 may overstate response rate performance for research surveys of broader populations because Dillman et al.'s (1998) results are based on participants who were contacted initially by phone and had agreed to participate in a Web survey, and Everingham's (personal communication, June, 2001) sample was of a closed population of employees at one company. Jones and Pitt (1999:556) sampled staff members at "10 universities whose staff directories were available on the WWW," and Couper, Traugott, and Lamias (2001) surveyed 1,602 University of Michigan students. In all these cases, the potential survey participants were likely to be more homogeneous and more disposed to respond than a random sample of the general population. In addition, university populations often tend to have greater access to the Internet, and today's college students can be expected to be more computer and Internet savvy.

In Table 2, we summarize the studies published in the literature in which respondents were allowed to choose to respond via either the Web or by mail, ordered in terms of the fraction who responded via the Web. Because for many populations, the fraction of respondents who can or will answer via the

TABLE 2
Studies Allowing Respondents to Choose a Web or Mail Response Mode

Study	Total Sample Size	% Choosing to Respond by: Mail	% Choosing to Respond by: Web	Overall Response Rate (%)	Population
Raziano et al. (2001)[a]	57	96	4[b]	77	U.S. geriatric chiefs
Sedivi Gaul (2001) and Griffin, Fischer, and Morgan (2001) (American Community Survey, 2000)	9,596	95	5	38	U.S. households
Sedivi Gaul (2001) and Griffin, Fischer, and Morgan (2001) (Library Media Center Survey, 1998)	924	95	5	38	Librarians
Sedivi Gaul (2001) and Griffin, Fischer, and Morgan (2001) (Library Media Center Survey, 1999)	13,440	81	19	63	Librarians
Quigley et al. (2000) (Department of Defense study)	21,805	77	23	42	U.S. military and spouses
Quigley et al. (2000) (Department of Defense study)	7,209	73	27	37	Civilians
Raziano et al. (2001)[c]	57	48	52[b]	58	U.S. geriatric chiefs
Zhang (2000)	201	20	80	78	Researchers
Schleyer and Forrest (2000)	405	16	84	74	Dentists[d]

NOTE: The multiple Quigley et al. (2000) and Raziano et al. (2001) entries represent multiple arms of the same study.
a. This arm of the study used mail as the contact mode.
b. Includes e-mail. The authors did not distinguish between e-mail and the Web as a response mode.
c. This arm of the study used e-mail as the contact mode.
d. The response mode in this case was either e-mail or fax.

Web may not be sufficiently large, and mail emerges as the most relevant second mode for a dual-mode survey, these studies are important.

In Table 2, we see that in most of the studies, respondents tended to choose mail when given a choice between the Web and mail. In fact, even when respondents are contacted electronically, it is not axiomatic that they will prefer to respond electronically (see, e.g., Raziano et al. 2001, who did not find a statistically significant difference in response rates). Zhang's (2000) and Schleyer and Forrest's (2000) are the only studies that contradict this conclusion, and they represent groups of respondents who were largely or entirely computer literate and comfortable with electronic communication. In comparison, the studies of Quigley et al. (2000) and Sedivi Gaul (2001)

TABLE 3
Studies with Multiple Study Arms: Comparing Response Rates for E-Mail, Web, and Mail Response Modes

Study	Total Sample Size	Response Rate (%) Web	E-Mail	Mail	Population
Tse et al. (1995)	400	—	6	27	University staff members
Tse (1998)	500	—	7	52	University staff members
Schuldt and Totten (1994)	418	—	19	57	Management information systems and marketing faculty members
Kittleson (1995)	153	—	28	78	Health educators
Mehta and Sivadas (1995)	262	—	40	45	Bulletin board service and newsgroup users
Couper, Blair, and Triplett (1999)	8,000	—	43	71	Federal employees
Schaefer and Dillman (1998)	904	—	53[a]	58	Washington State University faculty members
Parker (1992)	140	—	68	38	AT&T employees
Jones and Pitt (1999)	200	19	34	72	University staff members
Vehovar, Lozar Manfreda, and Batagelj (2001)[b]	1,800	32	—	54	Businesses in Slovenia
Pealer et al. (2001)[c]	600	58	—	62	Undergraduates at the University of Florida
McCabe et al. (2002)	5,000	63	—	40	University of Michigan students

NOTE: Dashes indicate not applicable; the indicated response mode was not evaluated in the study.
a. An additional 5% of surveys that were returned by mail are not included in this number.
b. An additional phone study arm achieved a response rate of 63%, and an additional contact-by-mail and response-by-fax study arm achieved a response rate of 43%.
c. In the second follow-up of both study arms, respondents were contacted by both mail and e-mail.

represent general cross-sections of the U.S. public in terms of computer literacy and availability, and in these studies, the fractions who chose the Web as the response mode were quite small.

In Table 3, we present studies that compared response rates between groups assigned to one of either two or three response modes. Here, we see that Internet-based surveys generally do not achieve response rates equal to those of mail surveys. (Table 3 is first ordered from lowest to highest e-mail response rate and then by Web response rate.) Further, Sheehan (2001) concluded that e-mail response rates are declining over time (though the reason for the decline is unknown).

Parker's (1992) is the only study of which we are aware in which e-mail achieved equal or higher response rates when compared to postal mail. Parker conducted a survey of 140 expatriate AT&T employees on matters related to corporate policies for expatriation and repatriation. He reported a 63% response rate via e-mail (63 surveys returned out of 100 sent by e-mail) compared to a 38% response rate for postal mail (14 surveys returned out of 40 sent by mail). Parker attributed the difference in response rates to the fact that at the time, AT&T employees received a lot of corporate paper junk mail, yet over the internal e-mail system, they received little to no electronic junk mail. Hence, the recipients of the paper survey were more likely to discount its importance compared to e-mail survey recipients. With the spread of e-mail "spam," this situation is likely to be reversed today.

In an example more typical of the current state of affairs and in one of the few studies to randomize respondents to mode, Couper, Blair, and Triplett (1999) obtained an average e-mail response rate of about 43%, compared to almost 71% with mail in a survey of employees in five federal statistical agencies. Couper, Blair, and Triplett chose e-mail over the Web as the mode for the survey because e-mail was almost universally available in the five agencies, whereas the Web was often not available.

Turning to the Web, McCabe et al. (forthcoming) conducted an experiment in which five thousand University of Michigan students were randomized to receive a survey about drug and alcohol use; half of the potential respondents received a mail survey, and half were notified of an equivalent Web-based survey. Respondents in both groups received a $10 gift certificate incentive. In this study, McCabe et al. achieved a 63% Web response rate, compared to 40% for mail. In contrast, however, Pealer et al. (2001) did not find a statistically significant difference between Web and mail response rates for a survey of undergraduates at the University of Florida.

The only other published study that achieved exceptional response rates with an Internet-based survey was that of Walsh et al. (1992), in which potential respondents were solicited by e-mail and offered the option to respond by e-mail or request a paper survey by postal mail. Although they did not conduct an equivalent postal mail–only survey for comparison (and thus are not listed in Table 3), Walsh et al. achieved a 76% overall response rate from a random sample of subscribers (three hundred out of a total population of eleven hundred) to a scientific computer network for an e-mail survey. In addition to providing nonrespondents with two follow-up reminders, a lottery prize of $250 was used as an incentive.

Walsh et al. (1992) found that 76% of the respondents replied by e-mail, and the other 24% responded by postal mail. They also received requests from an additional 104 subscribers (who were not chosen in the sample of

300) to participate in the survey. For the self-selected 104, 96% responded by e-mail. Not surprisingly, Walsh et al. also found a positive correlation between propensity to respond electronically and amount of network usage.

In conclusion, there is little evidence in the literature that Internet-based surveys achieve higher response rates, as a general rule, than conventional surveys. The few Internet-based surveys that have achieved higher response rates have tended to be either of university-based populations or small, specialized ones. The majority of results reported in the literature show that at best, Internet-based surveys currently achieve response rates equal to conventional modes and often do worse. The reasons for this difference are not yet clear and require more study.

Yet, as we have seen, there are also a few examples of Web surveys outperforming mail surveys for some specific populations. Whether this was idiosyncratic of these few surveys or an indication that a methodology is developing to achieve higher response rates in the new medium is yet to be shown.

Contrary to intuition, there is no published evidence that the concurrent fielding of a survey via a conventional mode and an Internet-based mode results in any significant improvement in response rates. This may be because, as Table 2 shows, except in specialized populations, when given a choice between mail and Web surveys, most individuals tend to respond to mail surveys. There is also no evidence that those who would normally refuse to complete a mail survey would choose to respond if the survey were Internet based. Of course, these results are specific to the current state of the art of Internet-based surveying, existing technology, and the current state of respondent attitudes toward surveys, both Internet based and conventional. Future developments may significantly alter these findings, and more research is warranted to learn how to improve the response rates of Internet-based surveys.

Finally, although research surveys based on probabilistic survey sampling methods are generally recognized as being necessary to conduct statistical inference to any population outside of the sample, convenience sampling can also be useful to some researchers for other purposes. For example, early in the course of research, responses from a convenience sample might be useful in developing research hypotheses. Responses from convenience samples might also help in identifying issues, defining ranges of alternatives, or collecting other sorts of noninferential data. In fact, in certain types of qualitative research, convenience samples on the Web may be just as valid as other methods that use convenience samples.

A number of studies in the literature used convenience samples to which response rate comparisons do not apply (hence precluding their inclusion in

Tables 1–3) because respondents were often recruited through advertising of some form. Although the response rates of these studies are meaningless, we present a few of the more interesting studies here to illustrate alternative ways that Web surveys can be used.

In a social science study of geographic mobility and other topics, Witte, Amoroso, and Howard (2000) recruited 32,688 respondents. Similarly, Vehovar, Lozar Manfreda, and Batagelj (1999) conducted a large-scale survey targeted at the Internet population of Slovenia, about 13% of Slovenia's total population. In both cases, similarly sized traditional mail surveys would likely have been more complicated and very expensive to carry out. Coomber (1997) conducted a survey of drug dealer practices in which his target population was illicit drug dealers throughout the world. Coomber solicited responses by e-mail and through advertising and collected responses on the Web, hoping that his respondents would be encouraged to respond more honestly because of a perceived anonymity.

Timeliness

In today's fast-paced world, survey timeliness is increasingly stressed. The length of time it takes to field a survey is a function of the contact, response, and follow-up modes. Decreasing the time in one or more of these parts of the survey process tends to decrease the overall time in the field. However, it is important to remember that the relevant measure is not average response time but maximum response time (or perhaps some large percentile of the response time distribution), because survey analysis generally does not begin until all of the responses are in.

Most studies tend to conclude, often with little or no empirical evidence, that Internet-based surveys are faster than surveys sent by postal mail. This conclusion is usually based on the recognition that e-mail and other forms of electronic communication can be transmitted instantaneously, whereas postal mail takes more time. However, this conclusion naively ignores the reality that the total amount of time required for fielding a survey is more than just the survey response time.

A complete comparison must take into account the mode of contact, how long that process will take, and the mode of follow-up, allowing for multiple follow-up contact periods. For example, if the e-mail addresses of respondents are unavailable and a probability sample is desired, then respondents may have to be contacted by regular mail. In this case, a Web survey saves time only for the return delivery of the completed questionnaire, not for the contact and follow-up, so the resulting time savings may be only a fraction of the total time for fielding the survey.

In e-mail surveys, in which the presumption is that the potential respondents' e-mail addresses are known and can therefore be used not just for delivering the survey but also for prenotification and nonresponse follow-up, the time savings can be substantial. For example, a week of delivery time must be allowed when using the postal mail. With an advance letter and a single mail follow-up, this one-week delay telescopes into over a month because two weeks must be budgeted for initial survey delivery and return time, plus an additional two weeks for a single follow-up reminder delivery and response time. By comparison, in an all-electronic process, the same operation has the potential to be completed in a few days or less.

Yet even in an all-electronic environment, it is not necessarily true that Internet-based surveys will be timelier. In a comparison of response speed between e-mail and mail, Tse et al. (1995) did not find a statistically significant difference in the time between the sending and receipt of an e-mail survey to university faculty and staff members and an equivalent survey sent by mail. Furthermore, to achieve sufficiently high response rates, it may be necessary to leave an Internet-based survey in the field for an extended period of time. For example, a prominent commercial Internet survey company, Knowledge Networks, has indicated that to achieve 70%–80% response rates, they must leave a survey in the field for about ten days. This constitutes one workweek with two weekends because most respondents complete their surveys on the weekend.

Some cases in the literature did show more timely responses. Tse (1998) found a statistically significant difference in the average initial response time for those who received an e-mail survey compared to those who received a paper survey in the campus mail (1 day vs. 2.5 days). Further, in Tse's experiment, most e-mail survey recipients either responded almost immediately (within 1 day) or did not respond at all, which raises the question of the effectiveness of nonresponse follow-up in the electronic forum. Schaefer and Dillman (1998) also documented faster e-mail response rates: Seventy-six percent of all responses were received in 4 days or less. Pealer et al. (2001) found a statistically significant difference in the average return time between their e-mail study arm (7.3 days) and their mail study arm (9.8 days). However, the final e-mail survey was received after 24 days and the final mail survey after 25 days, a negligible difference in overall fielding time.

In conclusion, although it is certainly reasonable to conclude prima facie that the delivery time of an Internet-based survey is faster than the delivery time of a survey by mail, it does not necessarily follow that the increased delivery speed will translate into a significantly shorter survey fielding period. Two points are relevant: (1) Dramatic improvements are possible

only with an all-electronic process, which is currently possible only for specialized populations; and (2) even for populations for which all-electronic surveys are possible, the literature is not very informative, because there is no information available about the length of fielding time required to achieve particular response rates.

Quality

When the primary purpose of a survey is to gather information about a population, the information is useless unless it is accurate and representative of the population. Although survey error is commonly characterized in terms of the precision of statistical estimates, a good survey design seeks to reduce all types of errors, including coverage, sampling, nonresponse, and measurement errors. (See Groves 1989 for a detailed discussion of the "total survey error" approach.) Indeed, even when a survey is conducted as a census, the results still may be affected by many of these sources of error.

Coverage error is the most widely recognized shortcoming of Internet-based surveys. Today, the general population coverage for Internet-based surveys still lags significantly behind the coverage achievable using conventional survey modes. However, there are some important caveats to keep in mind. First, the coverage differential is rapidly closing and may become immaterial in the relatively near future (though this is far from a preordained conclusion). Second, even though conventional modes have the ability to reach most of the population, it is becoming increasingly difficult to get people to respond (e.g., answering machines are routinely used to screen calls these days and hence screen out telephone surveyors and solicitors). Third, although conventional modes have near universal coverage, there will always be special subpopulations with little or no coverage for any mode. Fourth, access is only one consideration in Internet-based surveys. Even if a respondent in principle has Internet access (e.g., through a library), large portions of the population are still computer illiterate and would have difficulty responding correctly to such a survey. Finally, access and computer literacy are necessary but not sufficient conditions for success: Respondents must also have compatible hardware and software.

However, less than universal access to the Internet can be immaterial for some studies (e.g., studies that focus on closed populations with equal access or Internet users). To improve coverage, Dillman (2000) recommended a mixed-mode strategy for contact, using both e-mail and postal mail for prenotification. Similarly, using mixed response modes, such as the Web and e-mail, can increase coverage. However, as we mentioned previously, there

is little evidence in the literature that concurrent mixed-mode fielding increases response rates over what would have been achieved using a single, conventional mode.

In addition to coverage, data quality is a function of a number of other dimensions, including (1) unit and item nonresponse; (2) the honesty of responses, particularly for questions of a sensitive nature; (3) the completeness of responses, particularly for open-ended questions; and (4) the quality of data transcription into an electronic format for analysis, if required by the survey mode.

All other things held constant (such as prenotification and nonresponse follow-up), unit and item nonresponse are generally smaller using interviewer-assisted modes (de Leeuw 1992) compared to self-administered survey modes. Face-to-face interviews have long been considered the gold standard of surveys and tend to result in the lowest unit and item nonresponse as well as minimal respondent misinterpretation of questions and skip patterns. However, interviewer-administered survey modes, particularly face-to-face ones, yield more socially desirable answers than self-administered modes (Kiesler and Sproull 1986:409; de Leeuw 1992). This is particularly relevant for surveys of sensitive topics or for surveys that contain sensitive questions, such as questions about income or sexual practices, for example. Mail and other self-administered modes tend to be the least expensive but often have higher unit and item nonresponse rates. On the other hand, they tend to elicit the most accurate responses to sensitive questions.

Data quality is usually measured by the number of respondents with missing items or the percentage of missing items. For open-ended questions, longer answers are usually considered more informative and of higher quality. In studies that compare e-mail versus mail for closed-ended questions, e-mail surveys may incur a higher percentage of missing items than mail surveys. As Table 4 shows, in studies that reported the percentage of missing items, the percentage for mail respondents was less than or equal to that for e-mail respondents.

At the respondent level, Paolo et al. (2000) also found that 27% of e-mail respondents did not respond to at least one question, versus 9% for mail respondents. Kiesler and Sproull (1986) found the opposite: In the e-mail (contact and response) study arm, only 10% of respondents failed to complete or spoiled one item, compared to 22% in the mail (contact and response) study arm. Tse (1998) found no difference in the quality of responses.

For open-ended questions, studies have found that e-mail responses are either longer or of the same length as mail responses. Comley (1996) found that in two open-ended questions, e-mail respondents gave longer answers. One respondent even wrote a miniessay. Mehta and Sivadas (1995) found

TABLE 4
Average Percentage of Missing Items for E-Mail and Postal Mail Surveys

Study	*E-Mail*	*Postal Mail*	*Population*
Pealer et al. (2001)	14.2	14.2	Undergraduates, University of Florida
Bachman, Elfrink, and Vazzana (1996)	3.7	0.7	Business school deans and chairpersons
Comley (1996)[a]	1.2	0.4	Names and addresses purchased from Internet magazine in the United Kingdom
Paolo et al. (2000)	1.2	0.5	Fourth-year medical students
Couper, Blair, and Triplett (1999)[b]	0.8	0.8	Employees of five U.S. federal agencies
Mehta and Sivadas (1995)[c]	< 0.3	< 0.3	Active U.S. users of bulletin board systems and newsgroups

a. Based on three questions.
b. Based on eighty-one attitude questions.
c. Across five different study arms, one of which allowed for both mail and e-mail responses.

that there was "hardly any difference between the average completed responses for both the open and close-ended questions" (p. 436). Kiesler and Sproull (1986) found that the total number of words did not significantly differ for e-mail and mail respondents. If one also takes into consideration that open-ended items for mail respondents are not always encoded for cost reasons, it appears that Internet-based survey modes may be better suited to open-ended questions.

Other quality issues for Internet-based surveys resulting from some sort of sampling error are generally the same as for conventional surveys. However, as the Internet becomes more ubiquitous, collecting much larger samples becomes more feasible. Indeed, some organizations now have electronic access to their entire populations and are considering eliminating sampling and simply conducting censuses. Often, these census efforts result in much larger numbers of respondents than otherwise could have been gathered using traditional survey sampling techniques, and those larger numbers give the appearance of greater statistical accuracy. However, such accuracy may be misleading if nonresponse biases are not accounted for. Researchers need to consider carefully the trade-offs between smaller samples that allow for careful nonresponse follow-up and larger samples with less or no follow-up. The former may have larger standard errors but less bias, whereas the latter may have much smaller standard errors but an unknown and potentially very large amount of bias.

Finally, Web surveys offer the ability to clearly improve on other forms of self-administered surveys in terms of data validation, skip pattern automation, and the elimination of transcription errors, all of which help minimize measurement error. Web surveys can be programmed to conduct input validation as a logical check of respondents' answers. These types of checks improve data quality and subsequently save time in the preparation of the analysis file. As with logic checks, Web surveys can also be programmed to manage the process of skipping questions. This will eliminate errors and, from respondents' point of view, simplify the process of taking the survey. And although all conventional surveys require some form of conversion into an electronic format for analysis, in Web surveys, respondents' answers are directly downloaded into a database, avoiding transcription errors.

Cost

Designing a survey fundamentally involves trade-offs between the quality and quantity of data and cost. For smaller research surveys that are not subsidized in any way, a major component of the total cost is frequently the researchers' time for survey design and subsequent data analysis. However, these costs vary little by survey mode. A major expense that does vary by mode is the labor cost of those who actually execute the survey. Except in the case of very large mail surveys, depending on the complexity of the design, either researcher labor costs, survey personnel labor costs, or a combination of the two will likely dominate the survey budget.

Comparing the costs of doing a Web survey versus a mail survey or some other mode in the literature is difficult because different authors define costs in different ways. Academics frequently consider only postage and reproduction costs and often fail to account for the cost of one or more of various types of labor, including survey design and/or programming, coding, analysis, and other such items. Estimates also vary depending on whether they are given on a per-mail-out or per–complete survey response basis, and unfortunately, most studies in the literature don't discuss costs at all. Usually, though, the question often reduces to how to price the time spent programming a Web survey and whether and how to price the time of an investigator or a survey coordinator.

Lower costs are often touted as one of the benefits of Internet-based surveys, but Couper, Blair, and Triplett (1999) found no cost benefit to e-mail compared to postal mail surveys in their work. In a large and comprehensive survey effort of different government agencies, Couper, Blair, and Triplett compared an all-e-mail survey (contact, response, and follow-up) versus an all-mail survey. They found that evaluating and testing the e-mail software

took over 150 hours, almost four times as much time as they had budgeted. For the mail survey, the cost of printing and postage was $1.60 per reply, and data editing and entry cost about $1.81. For the e-mail survey, managing the e-mail cost $1.74 per completed case. In addition, they handled over nine hundred toll-free calls of a mostly technical nature. Although the printing and mailing costs were eliminated for the e-mail survey, Couper, Blair, and Triplett found that the costs of evaluating and testing the e-mail software, additional postcollection processing, and maintaining a toll-free phone line that was largely dedicated to responding to technical questions related to the e-mail surveys offset any savings. Further, almost 47% of the e-mail surveys required some type of clerical action to prepare them for automatic reading.

On the other hand, in a small study of 110 geriatric chiefs across the United States, Raziano et al. (2001) computed the cost per respondent for their mail study arm to be $10.50 and for their e-mail study arm to be $7.70. The programming time to construct the e-mail survey was factored into this calculation. However, the total programming time accounted for, two hours, may be unrealistic for a large or complicated survey operation. Also, these estimates fail to reflect the fact that their postal arm response rate from the first mail-out exceeded the e-mail arm response rate after four contact attempts. Hence, for a given desired response rate, the difference in costs would be less because fewer mailings would be required. Similarly, Schleyer and Forrest (2000) received responses over the Web, by mail, and by fax, and the total costs for the Web survey turned out to be 38% lower than for the equivalent mail survey.

Asch (as reported in Schonlau, Fricker, and Elliott 2002) found that adding a Web response option to a mail survey is economical when about 620 responses are obtained over the Web, when the Web is first used as the primary survey mode, and when surveys are mailed out only to nonrespondents. Schonlau, Fricker, and Elliott's calculations were based on the trade-off of the expected savings in postage, printing, and labor costs to prepare survey mailing packages and code the subsequent survey returns against the expected extra costs of programming, additional management effort, and maintaining a telephone help line for the Web survey. This study did achieve a cost savings because it garnered over one thousand Web responses.

In two studies that essentially ignored personnel costs, Mehta and Sivadas (1995) and Jones and Pitt (1999) concluded, not surprisingly, that Internet-based surveys are less costly than mail surveys. This stems from the fact that Internet-based surveys do not incur postage and printing costs, whereas mail surveys do.

In conclusion, when considering only postage and printing costs, e-mail and Web surveys, almost by definition, are cheaper than mail surveys. How-

ever, when the total costs of a survey are considered, Web surveys may or may not be cheaper depending on whether the additional expenses incurred with that mode (e.g., programmer costs) are offset by savings, such as postage and data entry costs. When planning for and subsequently executing a Web survey, care must be taken that unanticipated technical problems are minimized or that these problems can easily eliminate all potential cost benefits.

SUMMARIZING THE CURRENT PERFORMANCE OF INTERNET SURVEYS

In the introduction, we said that Internet-based surveys are in vogue, especially those conducted via the Web, primarily because of three assumptions: (1) Web surveys are much cheaper to conduct; (2) Web surveys are faster; and (3) combined with other survey modes, Web surveys yield higher response rates than the other survey modes by themselves. That is, the usual naive generalization about Internet-based surveys is that they are faster, better, cheaper, and easier than surveys conducted via conventional methods. How do these claims stand up when compared to what has been published?

Faster?

Web surveys are thought to be much faster than conventional survey modes. Although there is no question that the delivery time of an Internet-based survey is faster than a survey sent via the mail, there is little or no evidence to substantiate whether this increase results in a shorter overall fielding period. Two organizations that we know of have implemented all-electronic survey processes by communicating with respondents via e-mail, but this is currently possible only for prerecruited panels or specialized subsets of a population. If respondents must be contacted by mail or phone, which generally is the case if a probability sample is required by the research, then there may be only a marginal improvement in overall response time.

Better?

Response rates for Web surveys in which no other survey mode is given have ranged from moderate to poor. The reasons for this are not clear. It is possible that potential respondents simply do not respond as well to electronic solicitation or response. If true, this may improve as Internet-based

communication methods continue to spread and become routine with all segments of the general population. It is also possible that the execution of Internet-based survey experiments has been less than optimal, something that will improve with surveyor experience.

There are a few examples of Web surveys outperforming mail surveys in some of the more recent comparisons between these two modes. Whether this was a unique result for these few surveys or a leading indicator that the field is maturing and researchers are learning how to achieve higher response rates in the new medium is not known. In either case, improvements in these areas may be offset by oversaturation of the population with other forms of commercial surveys.

Setting the question of response rate aside, Web surveys offer some advantages over conventional modes. For example, if multimedia and/or interactive graphics are required, there are few conventional alternatives (and those alternatives, such as face-to-face interviewing, would likely be significantly more costly). If a convenience sample will suffice for the research, then the Web can be an excellent medium to use, particularly if the desired respondents are geographically diverse or hard to find or identify.

A major issue for Web surveys is that their ease of implementation facilitates naive misuse. The particular concern for this medium is that the easy collection of large numbers of surveys can result in surveyors and survey data consumers confusing quantity with quality. There is ongoing research about the effects of surveying via the Internet, the Web in particular, on unit and item nonresponse and on the effect the medium has on survey responses. Preliminary results have been reported at some conferences and symposia, but little has appeared in the literature as yet.

Cheaper?

The usual claim that Web surveys are much cheaper than mail surveys is not necessarily true. Web and e-mail surveys can save on some or all mailing costs, but except for very large surveys, these may be small costs in the overall survey effort. Web surveys can also eliminate data entry costs; e-mail survey results may not because they often require additional manipulation before they can be downloaded into an analytical database. However, savings in data entry may be partially or completely offset against higher programming costs and additional help desk staffing requirements. The literature mostly neglects labor costs, which are the highest cost component for Web surveys. Nonetheless, adding a Web survey to a mail survey can be cost-efficient if done carefully and properly.

Easier?

The implementation of Web surveys is technically more involved than mail or phone surveys. Survey designers need to specify many issues related to the technical control of Web surveys (e.g., how to move back and forth between questions, input validation, passwords, and for which questions are answers not optional) that are simpler or not required with conventional survey modes. Web surveys also require more extensive pretesting to ensure both that the questions elicit the desired information and that the program works properly across numerous hardware and software configurations.

The fielding process may or may not be made easier. Internet-based surveys have the potential to eliminate some of the more labor-intensive fielding tasks, such as survey package preparation and mailing and the subsequent data entry. Yet if mixed modes are required to obtain sufficient population coverage and/or response rates, then these tasks cannot be completely eliminated, and the fielding process may actually become more complex because support for two or more modes must be maintained and managed.

WHAT IS THE FUTURE OF INTERNET-BASED SURVEYING?

The first Internet browser was introduced only about a decade ago, and early use of the Web as a survey medium started only about five years ago. Significant research results about the use of this new survey medium have only recently begun to become available in the literature, and much is still unknown about Internet-based surveys. Although some predict that Web surveys will replace other survey modes, we expect Web surveys to develop into a distinct survey mode with advantages and disadvantages that will have to be weighed against the conventional alternatives.

For example, little is known about Web instrument design, the effects of instrument design on how survey participants respond to a survey or to a particular survey question, and what enhances response rates and response accuracy. At the 2001 American Association of Public Opinion Researchers conference, some anecdotal evidence was presented that respondents taking surveys on the Web had shorter attention spans, tending to browse the survey like they browse other Web sites. If true, long surveys and/or surveys with complex questions may not perform as well on the Web as by mail. Although many of the design principles from paper-based surveys may translate to Internet-based surveys, much more research is required.

To date, most Web surveys have been conducted on convenience samples or in organizations in which a list of target populations readily exists. However, Internet-based surveys with probability samples can be fielded by using the mail or the telephone for respondent contact and the Web for response. There is currently no equivalent to random digit dialing for e-mail. Even though the fraction of the population with access to e-mail will continue to grow, it is unlikely that one will ever be able to construct a random e-mail address in the same way that a random telephone number is constructed. However, large commercial e-mail lists may yet emerge that are of high enough quality to be useful in survey research.

A major challenge for researchers will be to distinguish themselves and their surveys from the plethora of commercial and entertainment surveys that exist and continue to multiply on the Web. These other surveys will continue to proliferate because the financial and technical barriers are so low for Web surveys. Thus, just as telephone survey response rates have continued to decline because of telemarketers, it is likely to become increasingly difficult to achieve superior response rates using the new medium.

Nonetheless, Internet-based surveys are here to stay. The challenge for researchers is to learn to use the new medium to their best advantage.

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Heuristic Mapping of Frontier Processes

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The value of analytical cartography and, in particular, of fuzzy set theory is demonstrated with regard to developing a specifiable and repeatable conceptual framework for multicriteria land evaluation. After a review of the distinguishing mathematical attributes of fuzzy set theory, including the derivation of the most useful functions, its application to the assessment of a 170,000-km^2 area of western Paraguay is described. Fuzzy set theory and multicriteria evaluation are shown to provide a robust framework for planning so that real-world interactions of interest at the management scale of conservation units are explicitly recognized. The Appendix gives the syntax for the four-step application procedure in Idrisi32 using an 8% fraction of the total study area and three geographic themes representing a point, a line, and a polygon coverage.

Conservation in Latin America is often built on time-invariant and spatially indeterminate legal norms inappropriate to the management units of interest. Such norms are inappropriate because they do not consider the influence of geographical distance, physical barriers, or institutional rigidities in the frontier settings where conservation activities are typically concentrated (Gragson 1994; Southgate and Whitaker 1994; Castellanet and Jordan 2002). The failure of legal norms typically stems from a lack of on-the-ground knowledge (i.e., data and information) and the use of conceptual paradigms limited to the static locational description of entities (Leung 1987; Wilson and Burrough 1999; Thwaites and Slater 2000). Because of data uncertainty and conceptual limitation, conservation is more often the consequence of

My research in the Paraguayan Chaco was made possible by funding from The Nature Conservancy (Arlington, Virginia), for which I gratefully acknowledge the guidance and support of Kent Redford, Patrick Ahern, and Fundación para el Desarrollo Sustentable del Chaco. George Luber and four anonymous reviewers provided useful comments on earlier drafts of the manuscripts that led to this article. Dr. Elgene Box graciously allowed me to use his program, SOLWTDEV, and took the time to explain how to format the data and interpret the results. The vector and raster coverages and the macro command file used in the Appendix are available on request.

Field Methods, Vol. 14, No. 4, November 2002 368–389
DOI: 10.1177/152582202237726